Deciphering the Impact of Basin Hydrodynamics on Marine Organic Productivity and Source Rock Distribution — Example Case from the Late Jurassic Arabian Intrashelf Basin

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Abstract

The prime producing source rocks of the extensive Late Jurassic Arabian carbonate platform were deposited within intrashelf basinal sequences. Along with the advancement of unconventional hydrocarbon exploration and productions, the distribution of source rocks and its compositional heterogeneities in intrashelf basins are becoming important subject of studies and key for the economic success. In the past decades, much research has been carried out in deciphering the processes that led to the accumulation and distribution of organic matter in time and space. Those research primarily focused on environmental factors such as water depth, sedimentation rate, primary productivity, carbon flux, oxygen level, and burial efficiency. However, very few have considered the impact of the hydrodynamics within the basin on organic matter deposition and possibly its transport in space. The premise that is proposed in this study is that surface and bottom currents in the intrashelf basin significantly impact marine organic productivity and deposition eventually controlling source rock distribution. The idea is to simulate hydrodynamic current patterns over the Callovian/Oxfordian Arabian carbonate shelf bathymetry and evaluate the impact of surface and bottom currents on the generation and deposition of organic matter in the intrashelf basin area. Results show that significant surface and bottom currents were likely present in the shallow intrashelf basin. Simulations indicate that surface currents commonly form eddies that are patchily distributed over the basin. These eddies likely caused vertical movement of deeper, slightly colder, high-nutrient waters to the surface thereby creating high-productivity upwelling zones. We deduce that primary marine organic production over the Arabian intrashelf was significantly influenced by unevenly distributed current patterns creating areas of higher and lower organic matter generation. At depth, where organic matter would have settled down, it is observed that moderate bottom currents may have caused reworking at the south-eastern part of the basin, with a major trend of sediment transport towards the north-western part of the basin interior where the bottom current velocities drop. Therefore, considering hydrodynamic simulations, the combination of surface and bottom currents are likely to have resulted in a laterally heterogeneous distribution of organic matter and hence source rock quality over the extent of the intrashelf basin. Hydrodynamic simulations of paleo-basins are likely the key to better understand the generation, distribution and accumulation of source rock/unconventional reservoirs, as well as serving as a predictive tool to generate more realistic subsurface models for hydrocarbon generation, expulsion and migration for the exploration of conventional plays.